Effector

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One can distinguish between three uses (and related definitions) of the term effector:

- In human beings;
- In control systems and robotics, where it is sometimes synonymous of actuator;
- And in robotics, where it may also refers to the tool attached to the last point in a robotic chain

Human beings effectors

In human beings, effectors are usually muscles, glands, or organs capable of responding to a stimulus, especially a nerve impulse.

Effector as an actuator element

In control systems and robotics, this term usually refers to a device used to produce a desired change in an object in response to certain inputs. It is also called actuator, which is in fact more appropriate to address its functionality. Then, it relates a fundamental function of artificial systems that involves control and energy flow mastering. In a haptic device [→ Haptics, haptic devices], the actuator is an essential and critical component: its properties are determinant for the device quality while its haptic function remains complex and subject of controversial definitions.

In a classical usage (robotics and mechanical controlled systems), the actuator is the device that makes the system able of an artificial action under the control of an artificial informational process (that may be either an automation data treatment process or a data transmission process).

In haptics, the actuator role differs mainly by the fact that a haptic device does not perform action, but is intended to be a substitute of natural object in human/object interaction situations, these behaviours being either the result of data transmission exchanges with a robot, or synthesized by a computational process. In this context the actuator has to fulfil two requirements:

- Its physical structure and sizing must be able to encompass a certain spectrum of different dynamical behaviours with sufficient precision regarding human sensibility and haptic task requirement. Among these behaviours passive ones are essential since the usual human environment of objects is mostly passive.
- By the means of its control input, the actuator must convey to the user's coupling environment the physical behaviour that is defined by the informational process (simulation or tele-coupling).

Various actuator technologies have been used in haptics. The most usual is the electrical technology which is based on electrical amplification and power electromechanical transducers, mainly electro-magnetic devices liked direct current motors or voice coils. Although the amplifier is the core element of the actuating function, the focus is usually shifted onto the electro-mechanical transducer because it constitutes the main bottleneck of this technology. Indeed energy conversion involves active materials (magnet and conductor) and the power and performance of electrical actuating system is directly linked to the quality and quantity of such material. Several other actuation technologies were used in haptics or are under developments.

Recent developments are focused on the usage of piezoelectric transducers. This technology could constitute an interesting alternate solution in the family of electric amplification based systems since piezoelectric devices offer higher specific force and power than the classical electro-magnetic transducers.

The piezoelectric transducers can provide interesting alternate solutions to electromechanical energy conversion since piezoelectric devices offer higher specific force and power than the usual electro-magnetic transducers. The application of this technology to haptics is still under development.

In a second category there are the circulating fluid actuators that are based on the control of the power of a air or oil flow. The advantage on electrical systems relies on the higher efficiency of the fluid/mechanical converter element that is constituted of a simple piston.

Finally other haptic actuators are based on direct electro-mechanical amplification technologies that need no energy conversion. There are (1) the electrically controlled clutches or brake systems, (2) the direct contact magneto-rheological fluid systems and finally (3) the variable transmission ratio control systems (CVT) that were mainly developed for cobotic applications. The absence of an energy converter is a significant advantage on electric and fluid technologies since the power transducer is always a critical and performance limiting element.

Effector as the tool attached to the last point in a robotic chain

In robots and in haptic devices, the term end-effector refers to a device or tool connected to the end of the robot arm or the mechanical part manipulated by hand in haptic device. Its structure depends on the intended task. In conventional robots, grippers are the most functional end-effectors used to manipulate real objects.

In haptic devices, the user grasps the end-effector of the interface. The shape of the end-effector may correspond to the virtual tool that the user is manipulating in the virtual environment. It can be whether a kind of stylus to simulate pens, pencils, screw drivers, etc. (as in PHANToM, Mirage F3D-35, Haptic Wand, LHIfAM, etc.), whether a handle or joystick (as in Virtuose 6D35-45, EXCALIBUR, DLR-LWR-III, etc.), whether a ball (as in DELTA, OMEGA, Haptic-MASTER, etc.). It can also consist in a thimble-gimbal or a glove to allow the user to directly feel contact forces without using or simulating any intermediate tools. In some cases, the user can change the end-effector (such as in ERGOS haptic technology [Florens & al, 1990], in which several types of the end-effectors can be plugged on a sensor-actuator basement).

The way the user grasps the end-effector has been deeply studied. Grasping geometry has been classified in two categories, namely power and precision grasps. Power grasp has high stability and force, because the whole hand and palm are used, but they lack dexterity (fingers are locked on the grasped object). Conversely, precision grasps exert less force but have higher dexterity since only the fingertips are used. Typical power and precision grasping configurations can be consulted in [Cutkosky & Howe, 1990].

References

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